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Dorendorf et al.

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(54) **SPRAYING DEVICE, SYSTEM AND METHODS OF DISPERSING AND DISSEMINATING MATERIALS**

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Related U.S. Application Data

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(51) **Int. Cl.**[7] **A62C 31/00**; A62C 5/00; B05B 7/04; F23D 11/36; F23D 11/40

(52) **U.S. Cl.** **239/398**; 239/318; 239/77; 239/411; 239/418

(58) **Field of Search** 239/398, 318, 239/77, 411, 418, 407–409, 412–414, 104, 114–118, 302, 310

(56) **References Cited**

U.S. PATENT DOCUMENTS

2,201,995	A		5/1940	Erickson	
3,239,960	A		3/1966	Stevens	
3,304,011	A		2/1967	Paasche	
3,735,929	A	*	5/1973	Pleines	239/341
3,776,459	A		12/1973	Bonvicini	
3,900,165	A	*	8/1975	Parke et al.	239/375
3,917,168	A		11/1975	Tenney	
4,116,385	A		9/1978	Waldron	
4,474,327	A		10/1984	Mattson et al.	
4,781,329	A		11/1988	Tenney et al.	
5,299,737	A	*	4/1994	McGinnis et al.	239/77
5,340,026	A		8/1994	Woodruff	
5,392,996	A		2/1995	Ussery	
5,441,297	A		8/1995	Krohn et al.	
6,003,787	A		12/1999	Fisher	
6,012,647	A		1/2000	Ruta et al.	
6,409,097	B1		6/2002	McCauley	
2002/0030117	A1		3/2002	Bryan et al.	

FOREIGN PATENT DOCUMENTS

EP	0 131 120	A1	5/1984

OTHER PUBLICATIONS

Manual for "BOA Flow Control Belt Operated ASP Pump: Instruction Manual With Parts List", Lowndes Engineering Co., Inc., Valdosta, Georgia.

Manual for "LECO CV Flow Control With Digital Meter: Manual Supplement for Digital Meter Effective Serial No. 6700756—up", Lowndes Engineering Co., Inc., Valdosta, Georgia.

(List continued on next page.)

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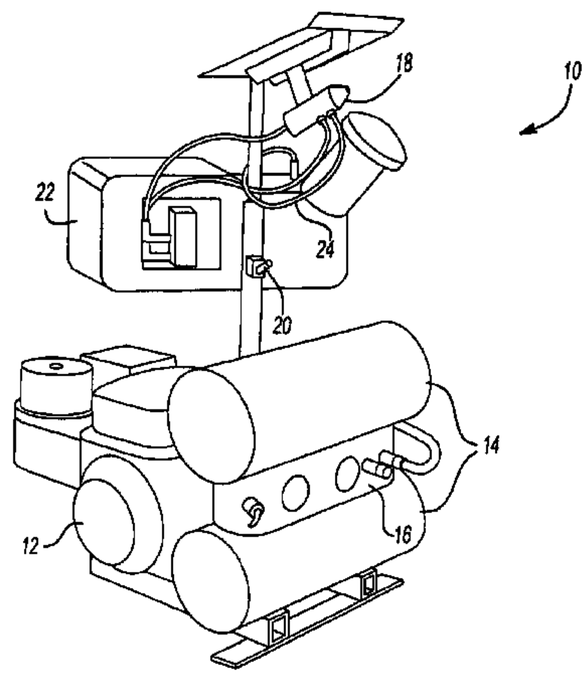
(57) **ABSTRACT**

The invention includes a spraying device **(10)** for producing a precise degree of liquid droplet generation on a repeatable basis by combining a specified rate of regulated flow of liquid material with a regulated flow of high-pressure air. The spraying device **(10)** includes an electric or engine driven direct drive compressor **(12.)** Coupled to the compressor **(12)** is an air storage tank **(14)** providing air pulsation reduction to the regulated air and serves as a reservoir for excess airflow generation. A Venturi nozzle **(18)** is connected to the compressor **(12.)** A liquid supply tube **(24)** uses a fixed or variable restriction to regulate the liquid flow to the nozzle **(18.)** The vacuum in the liquid supply line **(24)** draws this liquid flow and mixes the liquid externally with the regulated air in exacting proportions forming specified liquid droplet sizes. The device **(10)** uses air and liquid regulation combined with a Venturi nozzle **(18)** and is able to generate extremely consistent liquid droplet sizes.

13 Claims, 9 Drawing Sheets



OTHER PUBLICATIONS

Manual for "LECO CV–E Flow Control With Digital Meter: Manual Supplement For Digital Meter Effective Serial No. 6900192—up", Lowndes Engineering Co., Inc., Valdosta, Georgia.

Manual for "LECO CV Flow Control: Instruction Manual and Parts List", Lowndes EngineeringCo., Inc., Valdosta, Georgia.

Manual for "LECO ULV Fog Generator Model HD", Lowndes Engineering Co., Inc., Valdosta, Georgia.

Manual for "LECO Model P–1 ULV Fog Generator: Instruction Manual and Parts List", 1989,1991 Lowndes Engineering Co., Inc., Valdosta, Georgia.

Manual for "Model Mini II ULV Fog Generator: Instruction Manual and Parts List", 1990 Lowndes Engineering Co., Inc., Valdosta, Georgia.

Manual for "Model 500 ULV Fog Generator: Instruction Manual and Parts List", Lowndes Engineering Co., Inc., Valdosta, Georgia.

Textbook titled "Lowndes Engineering Co., Inc. Equipment School : Quality is Economy", Lowndes Engineering Co., Inc., Valdosta, Georgia.

* cited by examiner

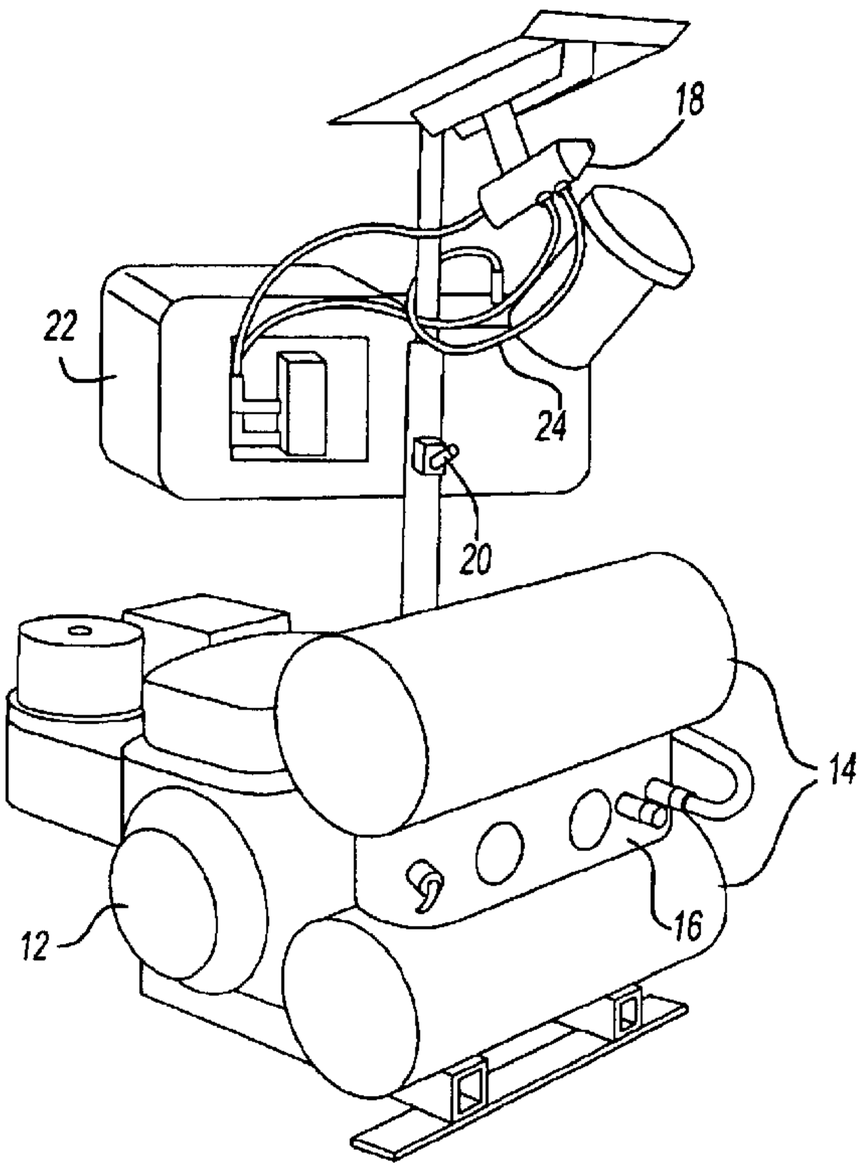


Fig-1

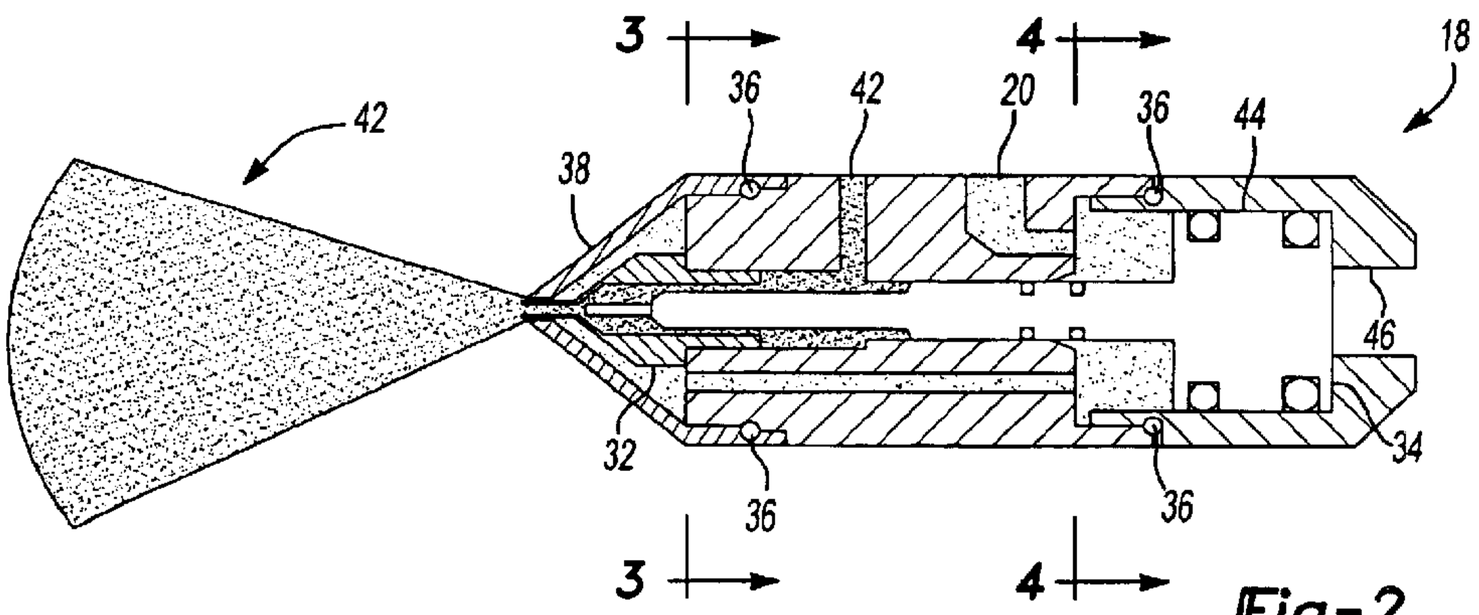


Fig-2

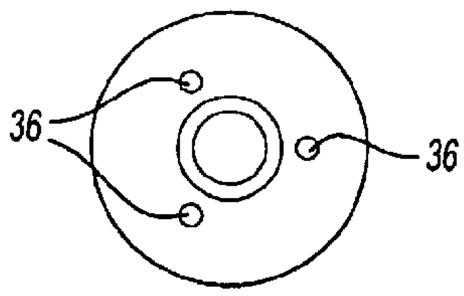


Fig-3

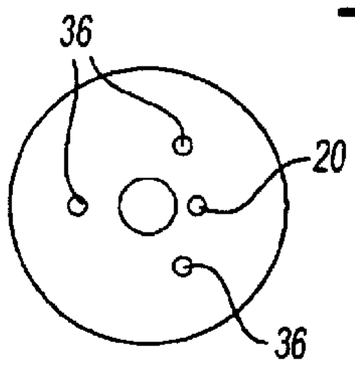


Fig-4

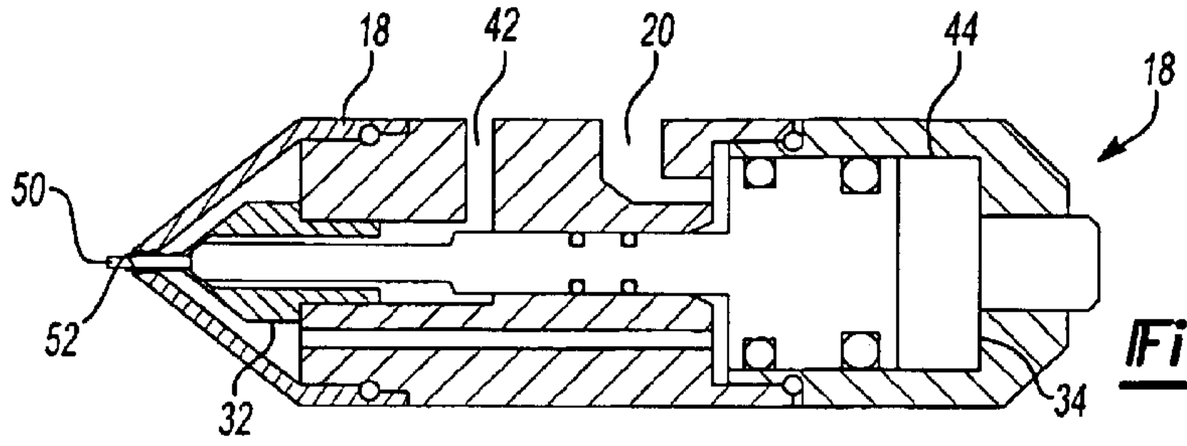


Fig-5

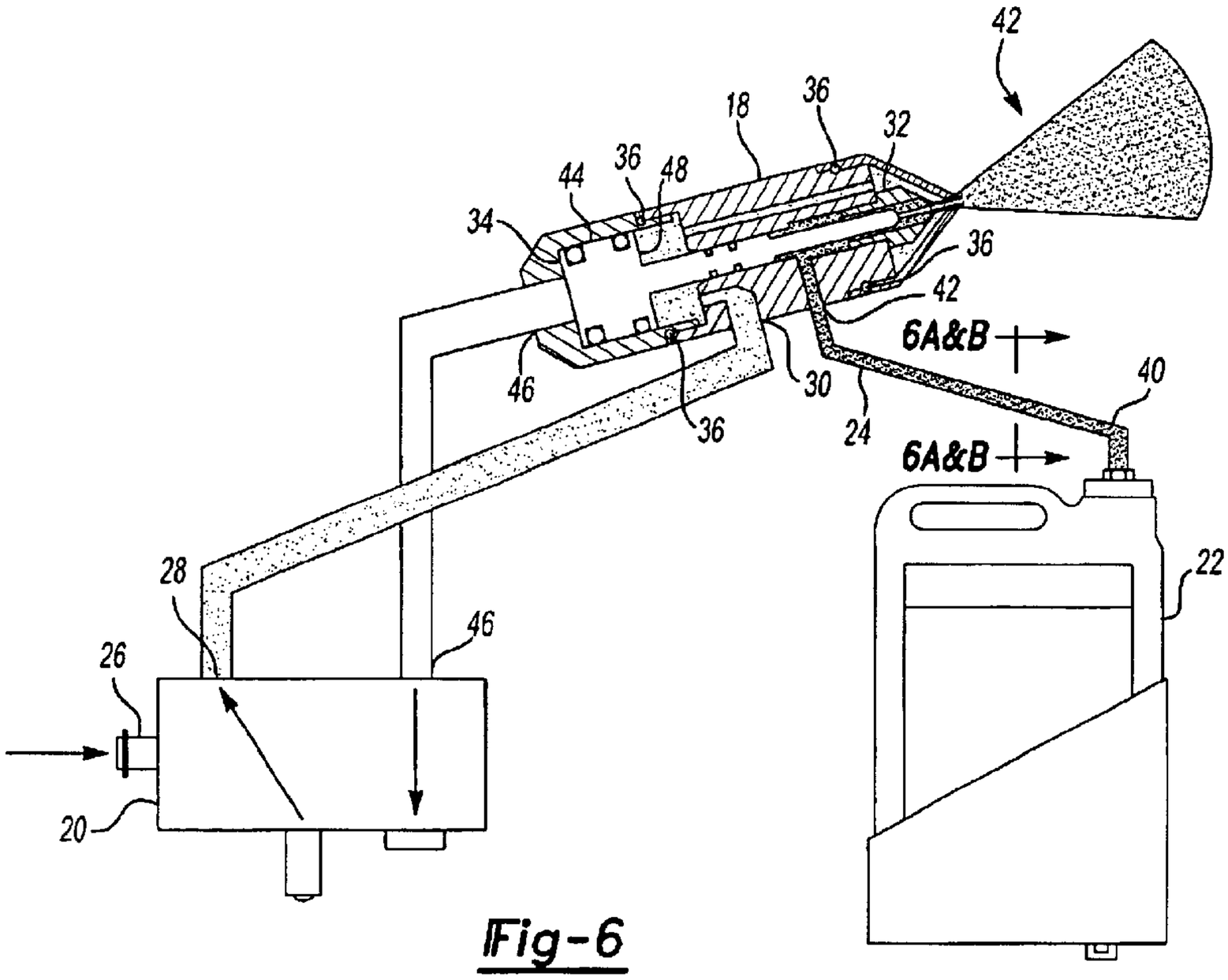


Fig-6

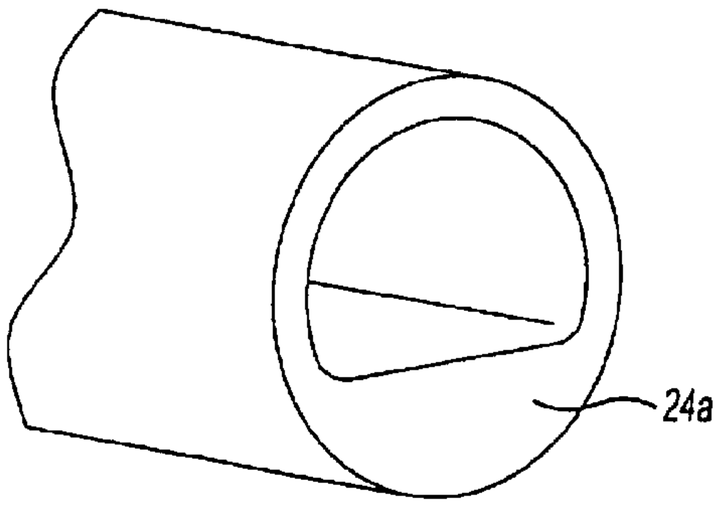


Fig-6A

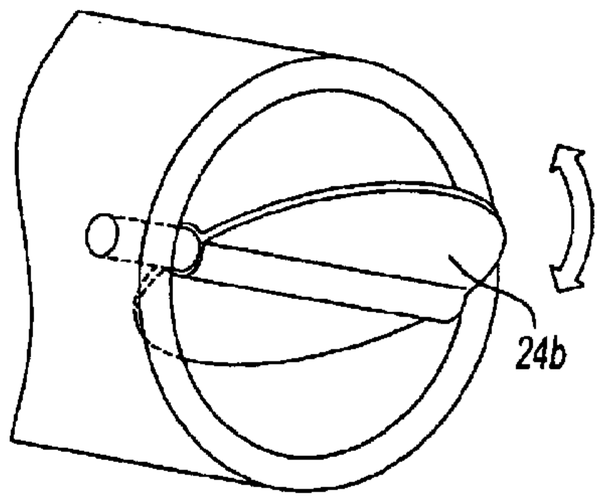


Fig-6B

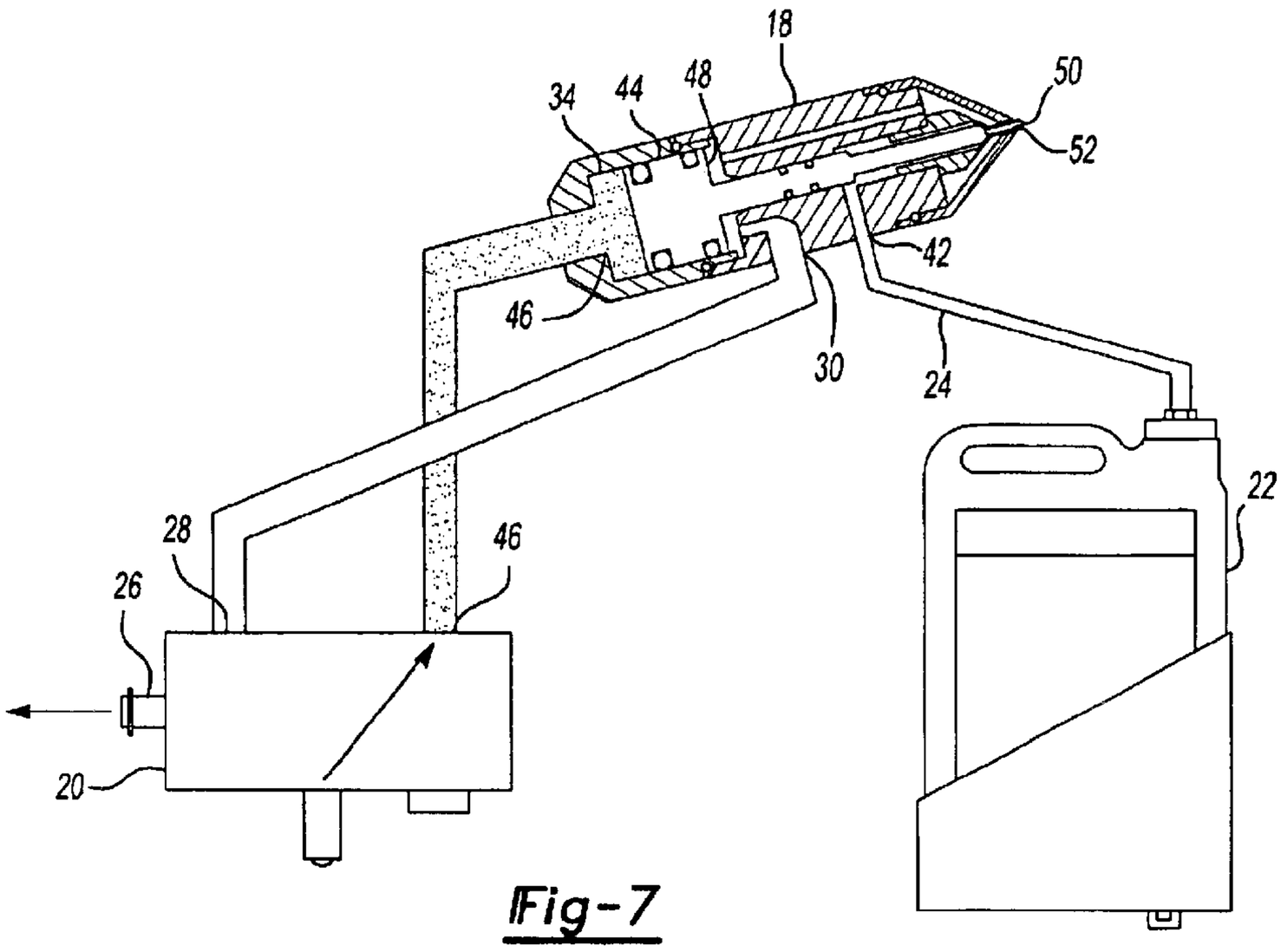

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Fig-7

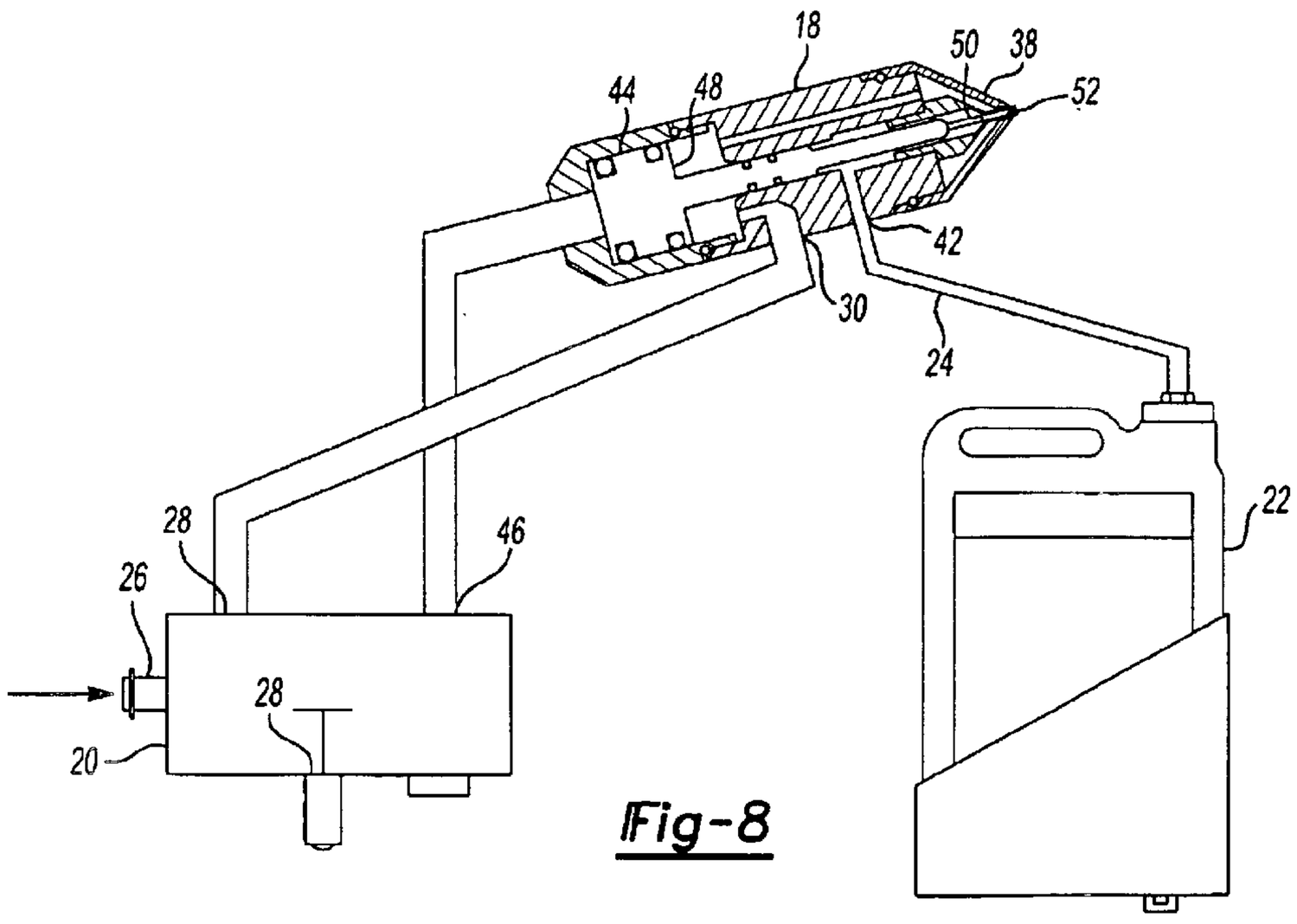
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Fig-8

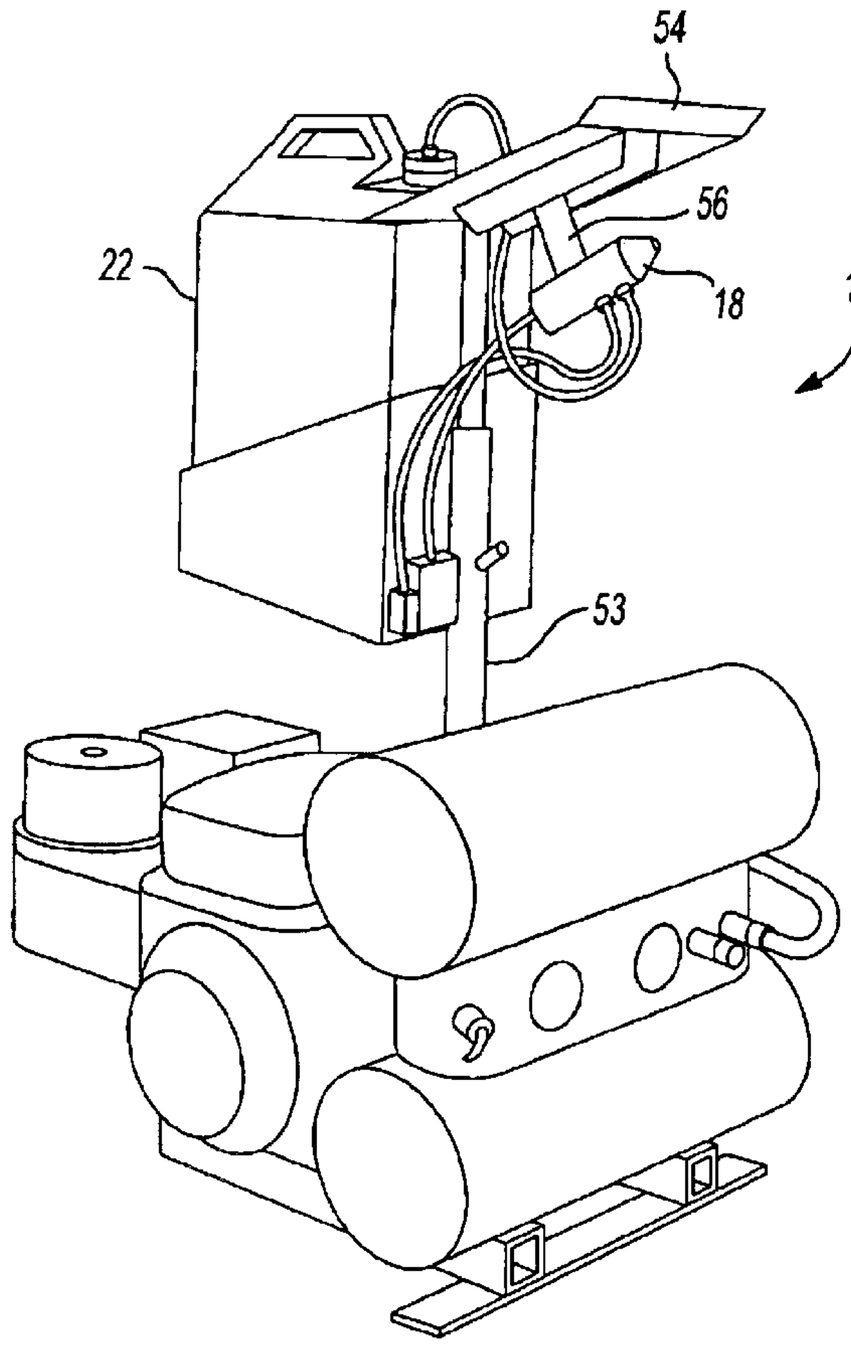

Fig-9A

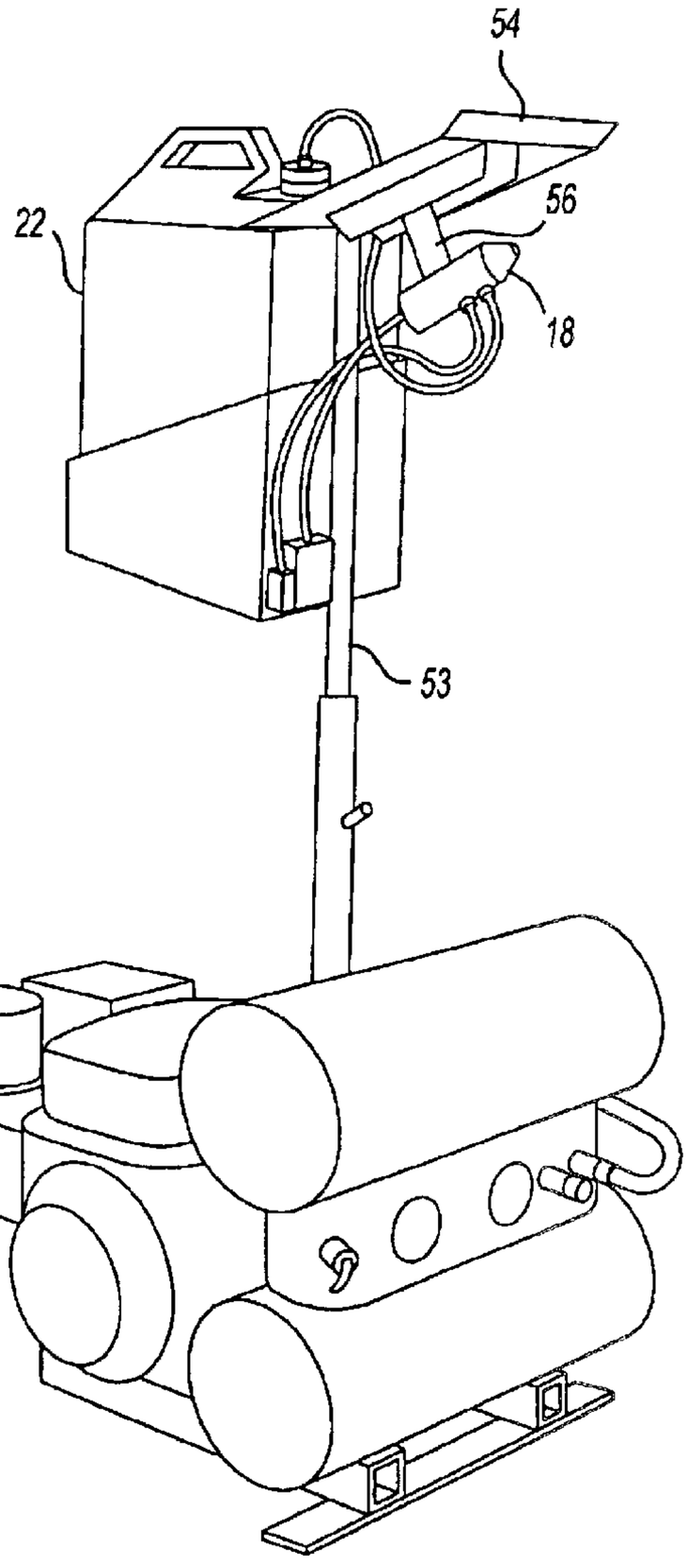

Fig-9B

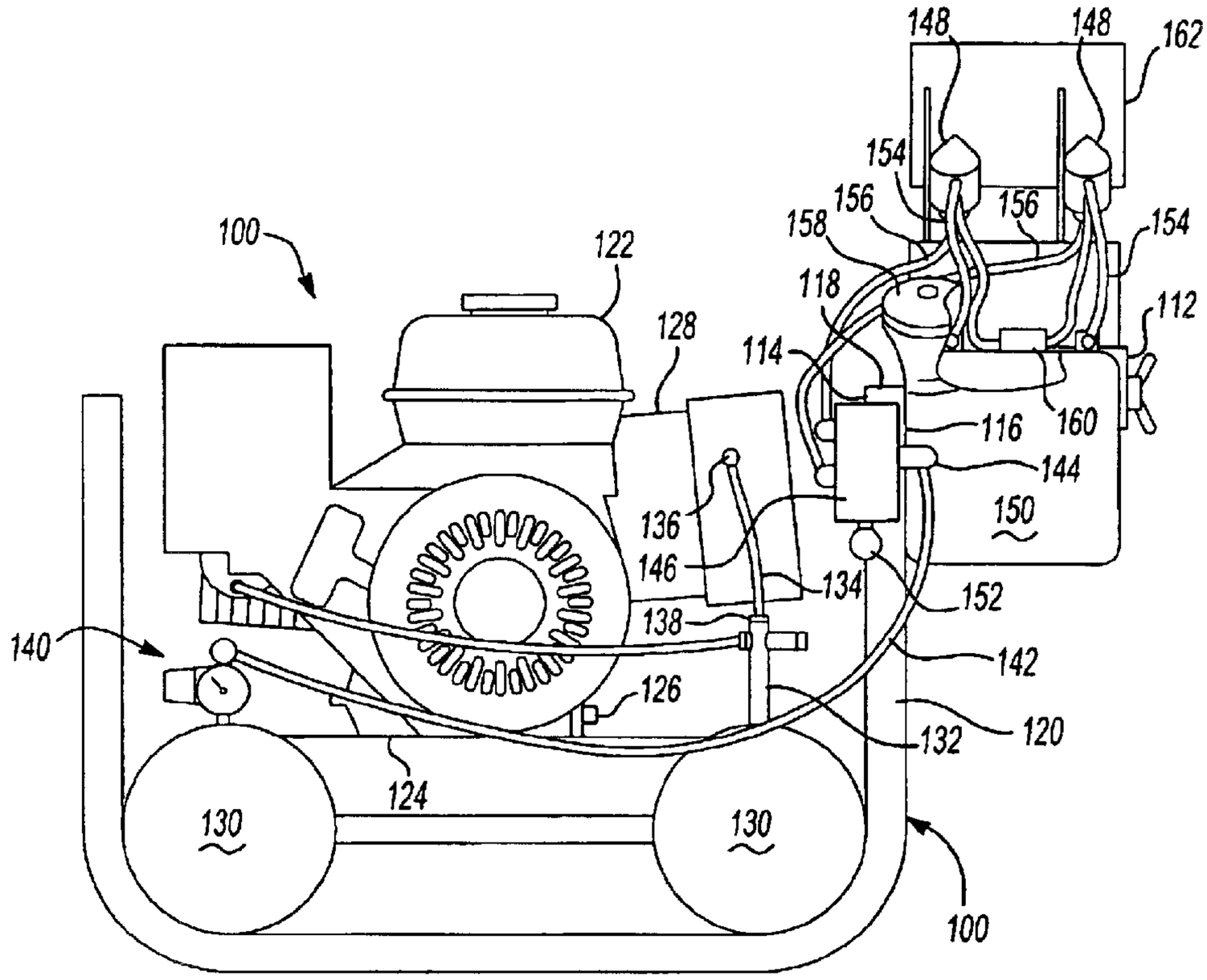
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Fig-10

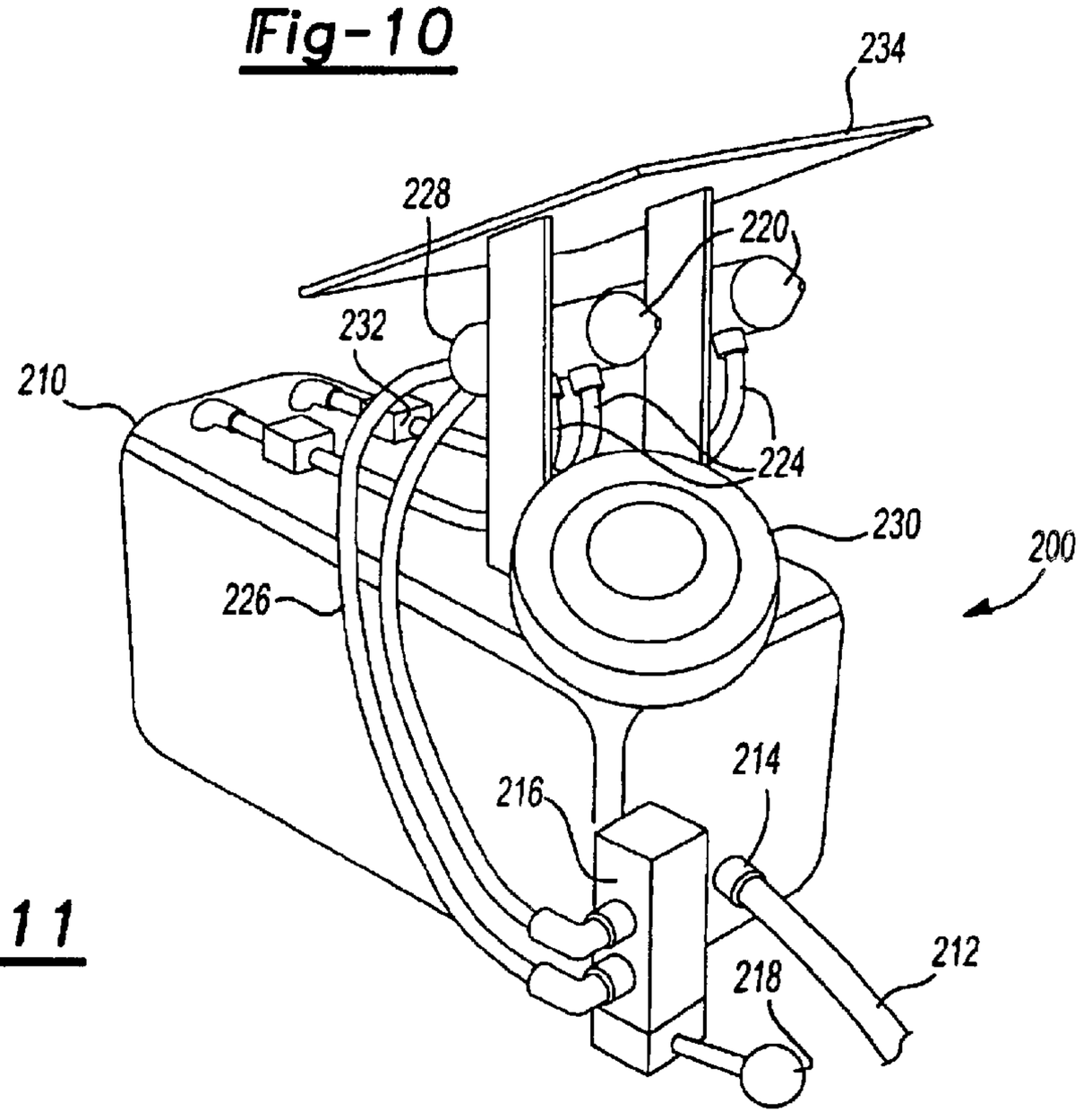
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Fig-11

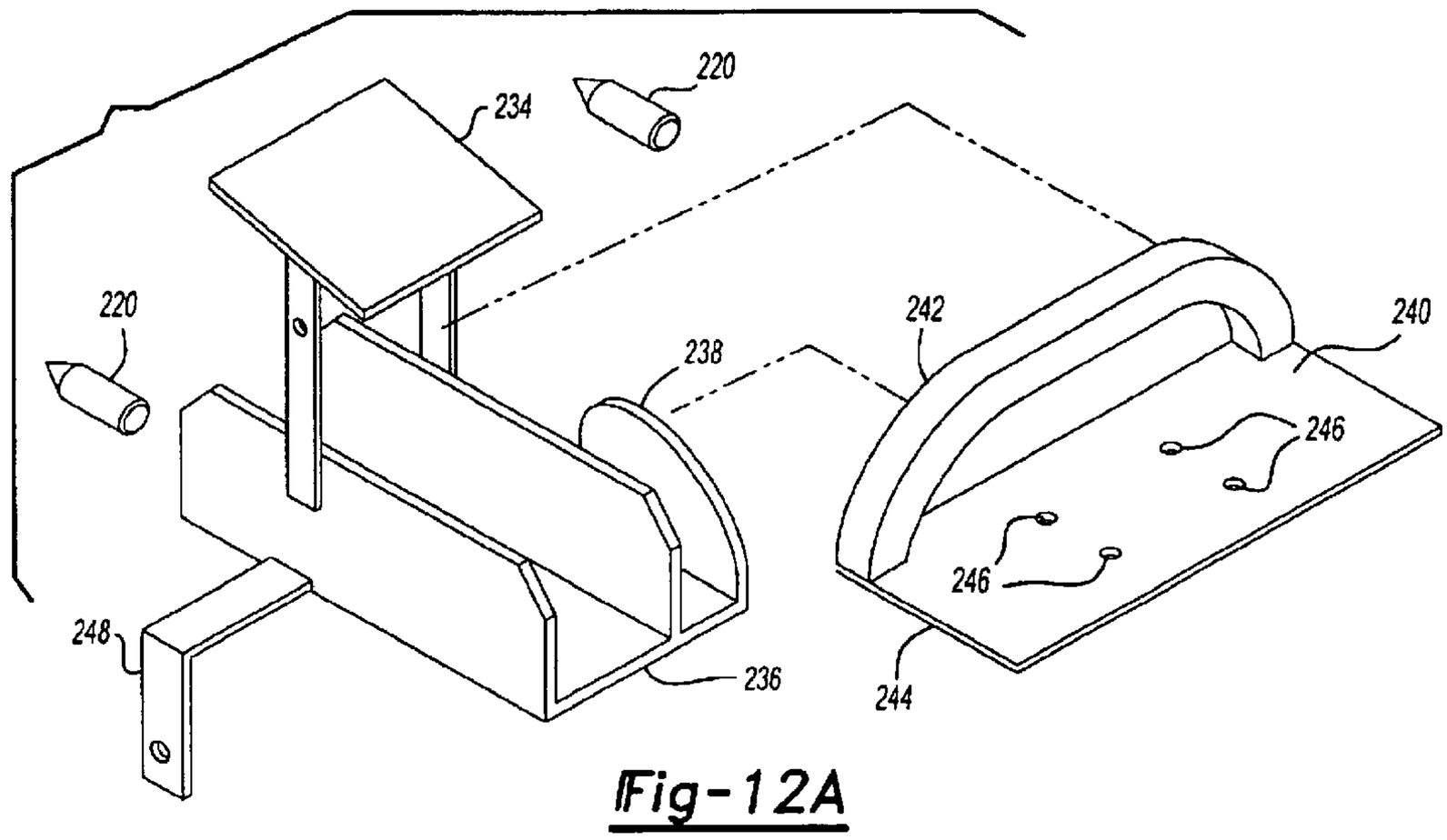

Fig-12A

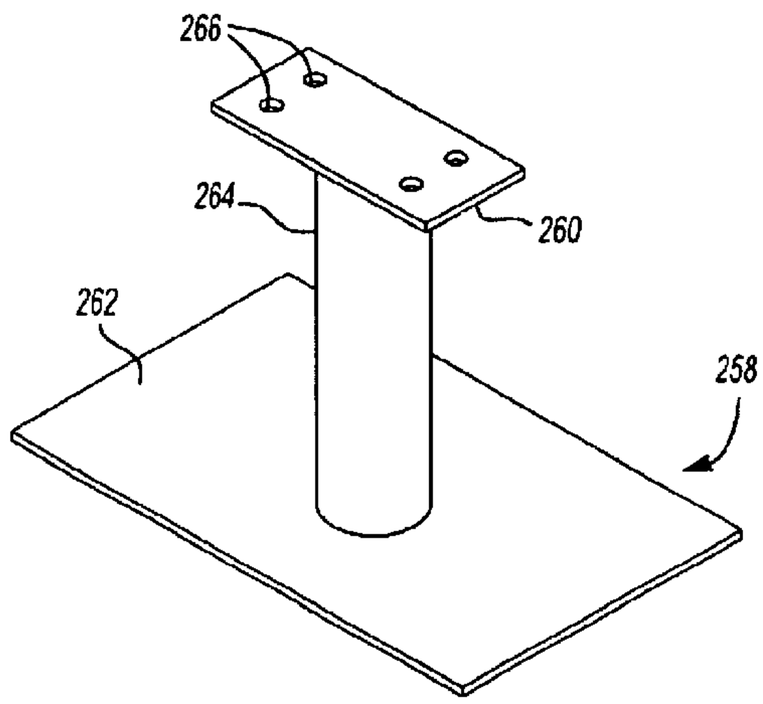

Fig-12B

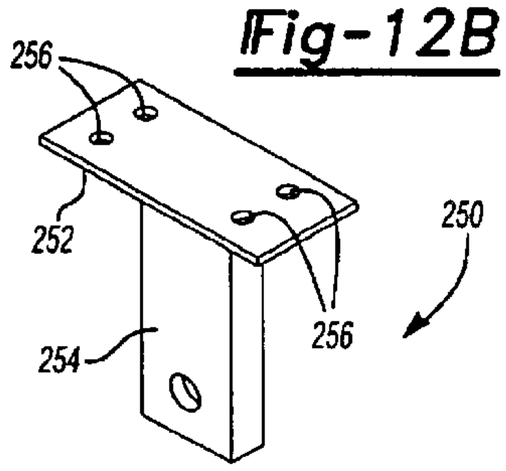

Fig-12C

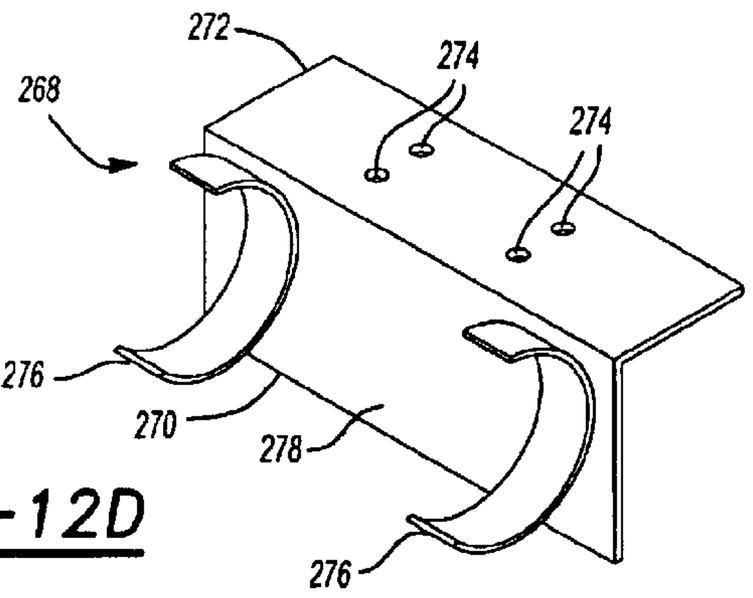

Fig-12D

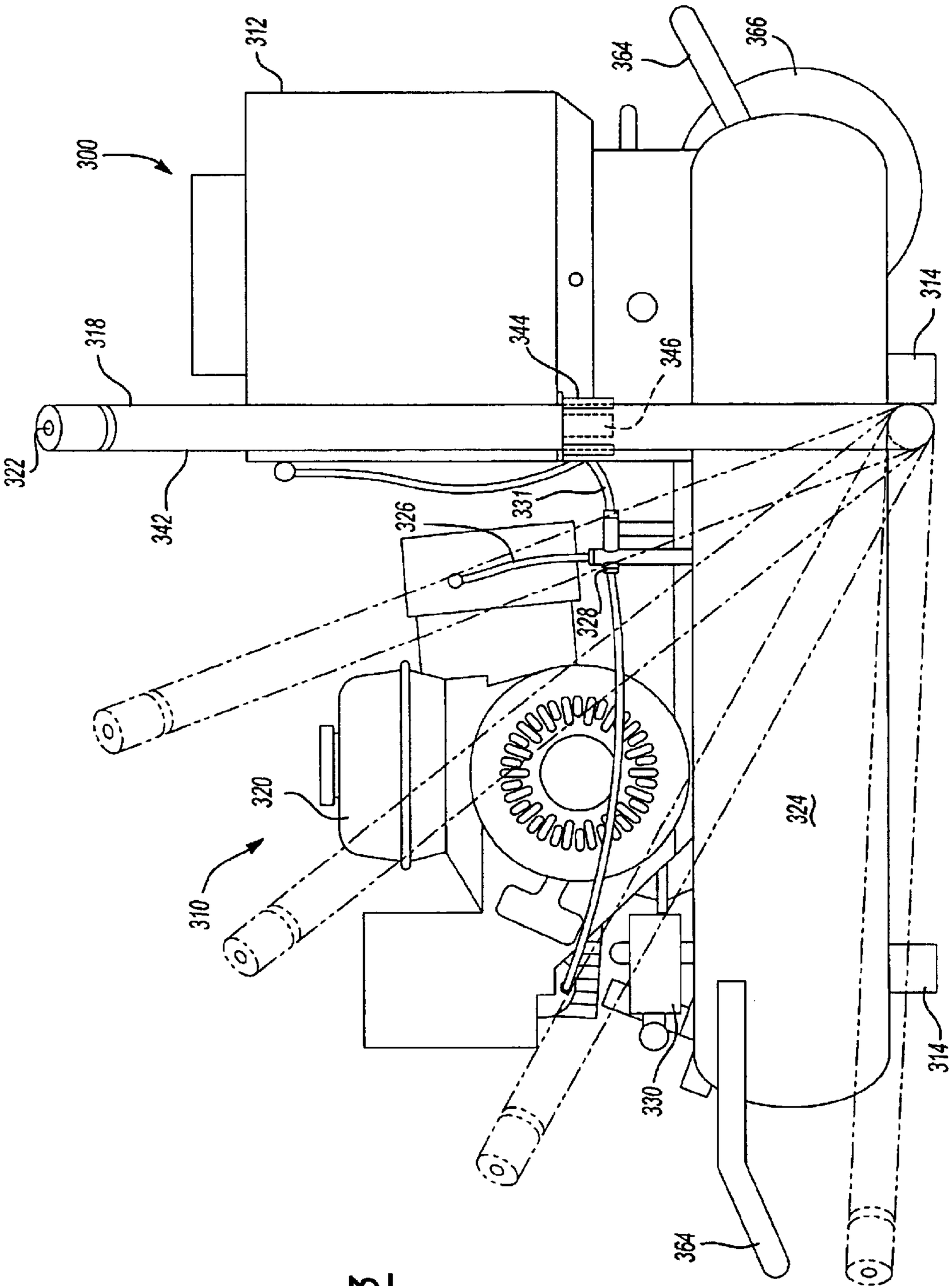
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Fig-13

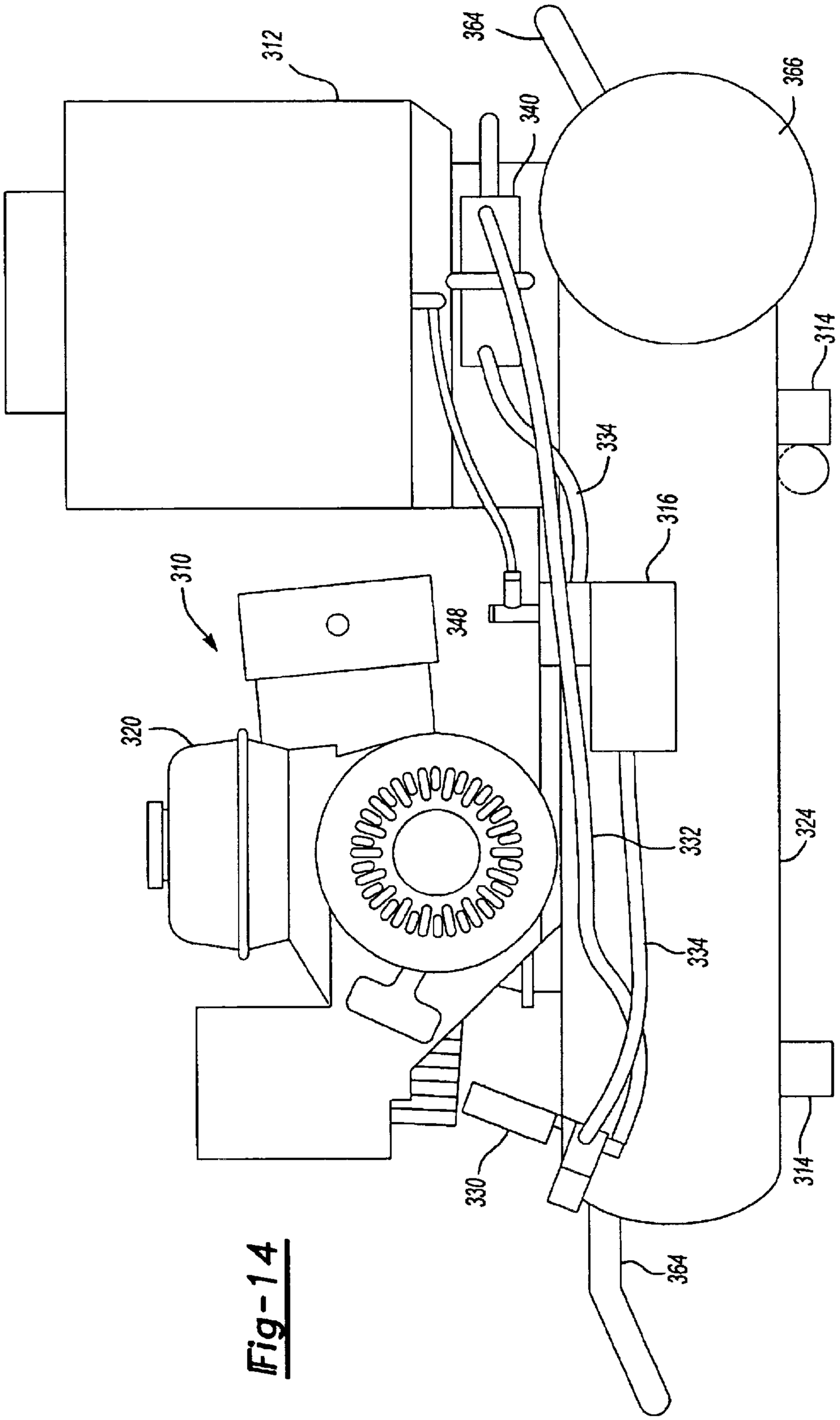

Fig-14

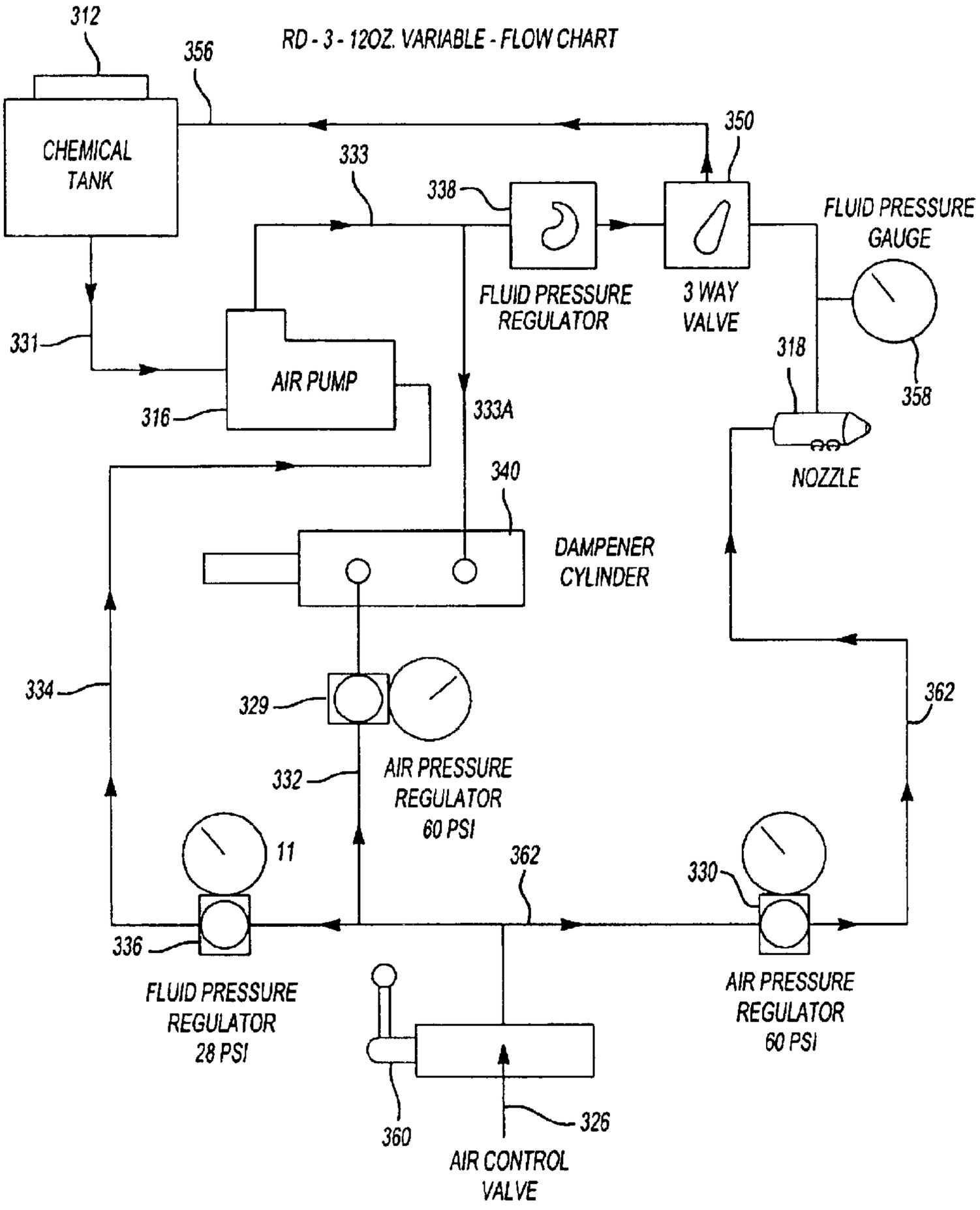
312
RD - 3 - 12OZ. VARIABLE - FLOW CHART
356
CHEMICAL TANK
350
333
338
FLUID PRESSURE GAUGE
FLUID PRESSURE REGULATOR
3 WAY VALVE
331
AIR PUMP
316
333A
318
358
NOZZLE
340
DAMPENER CYLINDER
334
329
AIR PRESSURE REGULATOR 60 PSI
332
362
11
362
330
336
FLUID PRESSURE REGULATOR 28 PSI
AIR PRESSURE REGULATOR 60 PSI
360
326
AIR CONTROL VALVE

Fig-15

SPRAYING DEVICE, SYSTEM AND METHODS OF DISPERSING AND DISSEMINATING MATERIALS

This application claims the benefit of Provisional Application No. 60/341,326 filed Dec. 13, 2001.

TECHNICAL FIELD

The present invention relates generally to an improved device, system, and method for the spraying and application of liquids and/or liquid-gas mixtures for a number of purposes such as: insect control/eradication, pesticide applications, medicinal or medical product spraying applications, including spraying antibiotics among livestock, chickens, pigs, etc. and antidotes for potential terrorist activities, herbicide applications, insecticide applications, paint applications, misting applications, cooling applications, water applications, fertilizer applications, horticultural applications, solid-stream applications, and application of cleaning/stripping/degreasing solutions for household and industrial uses. More particularly, the present invention relates to a cost effective, low-maintenance, and transportable liquid spraying system for the efficient application of liquid materials used to control insect populations, such as mosquito control products.

BACKGROUND OF THE INVENTION

Traditional mosquito control methods and spraying systems utilized and found in the prior art generally consisted of thermal smoke generators. Typically, this device or process involves the creation of a gaseous smoke that serves as a carrier for the selected insecticide, pesticide, water, petroleum or synthetically formulated liquids. The use of thermal smoke generators, particularly when mounted on motorized vehicles, can often create visual obstructions and lead to dangerous spraying conditions, especially in residential areas. In addition, the application of the gaseous smoke can be inefficient, uneven, require a large amount of pesticide to be integrated with the gaseous smoke, and can be poorly targeted due to the influence of ambient environmental and weather conditions, such as wind, topography, etc.

More recently, spraying techniques have begun to utilize Cold Aerosol Ultra Low Volume (ULV) generators to disperse insect and mosquito control products. Ultra Low Volume technology provides a light cloud of spray comprising a very specific size of droplet. The use of Ultra Low Volume generators typically allow an efficient delivery of a very specific amount of liquid or chemical to the targeted areas inhabited by insects, such as the mosquito, thereby reducing the amount of liquid chemical required for spraying. Typically, the Ultra Low Volume spray clouds are generated through the use of either gas driven blowers or electrically driven rotary sleeves. The Ultra Low Volume blowing equipment can produce a significant amount of undesirable emissions and comprise a number of components which need to be maintained and/or calibrated, such as pumps, meters, flow controls, and filtering devices. In this regard, the expense of such equipment is often cost prohibitive to many smaller municipalities, commercial applicators, or homeowner/development groups that seek to provide mosquito control and insect spraying services to its citizens and residents.

While these prior art devices can perform well and do effectuate mosquito control in many circumstances, they often require a large capital investment to place the equipment into service, utilize a large amount of maintenance

resources during operation as well as storage space during periods of non-use, and require additional labor demand to monitor and maintain the systems to ensure that they are in working order when needed. For instance, multi-component Ultra Low Volume spraying packages often require placement and mounting upon dedicated spraying vehicles. In turn, the entity or organization charged with responsibility for the spraying application process is required to devote both financial and technical resources to transportation the multi-component equipment during operation and justify the expenses to its respective constituency, residents, or other recipients of the spraying services.

Moreover, in recent years, state and federal health agencies and organizations in the United States have documented the introduction and spread of a number of viruses and diseases that have been traced to airborne-carrying insects, such as the mosquito. For example, the West Nile Virus and forms of malaria and encephalitis have been identified in both human and animal subjects. In some cases, these viruses have been fatal to humans with children and the elderly being particularly susceptible. At the same time, state and federal environmental legislation and environmental preservation causes have sought protection for "wetlands" areas to preserve the natural environment in designated areas which may be directly adjacent to areas inhabited by human residents. Although preservation of natural resources and the ecosystem are important objectives, a traditional "wetlands" area is generally conducive to the habitation and breeding of large numbers of mosquito populations. Given the airborne and mobile nature of a flying insect, such as the mosquito, the mosquito population often comes into contact with human inhabitants living nearby.

In response to these newly documented health dangers being carried by the mosquito and potential human transmission of life-threatening diseases through contact with the mosquito, both the public and governmental authorities have focused on the need to protect residential populations through cost-effective mosquito control management programs. In so doing, one of the clearest and basic needs is to provide physical equipment and infrastructure to facilitate the application of spraying techniques to control the mosquito population in residential areas.

Accordingly, there is need for a simple low cost system and spraying technique that provides an integrated and dependable application of selected liquid materials to designated geographic areas.

SUMMARY OF THE INVENTION

The present invention is directed to a spraying system and techniques/methods for the application of liquid materials to targeted portions of the ambient environment, and particularly one for the efficient spraying of selected liquid droplets, such as (without limitation) liquids employing chemical formulations for insect control/eradication, herbicide application, insecticide application, paint application, water application, fertilizer application, antibiotic application and application of cleaning, stripping, and degreasing solutions for household and industrial uses. Although it is contemplated that the present invention has particular application and utility in the field of spraying and disseminating formulations and agents to facilitate mosquito and insect control thereby protecting human populations from diseases and pathogens, such as the West Nile Virus, malaria, and various forms of encephalitis, it should be seen that the present invention may also be utilized to deliver formulations and agents to control mosquitos and various insects among

animal and livestock populations, zoos, food production facilities that utilize live animals, and game preserves. Further, the present invention could be utilized to deliver airborne medical products, vaccines, and antidotes to both human and animal populations in response to a specific medical or epidemiological event. The system generally employs a kit or combination of spraying equipment which is lightweight, compact, and requires a relatively low level of maintenance on the part of the entity applying the materials. The system functions through the spraying of accurate and efficient droplets through the combination of fluid and air by means of a low emission engine or other power source and a compressor. It is contemplated that the present invention may further comprise a dual-use feature having functionality as an air compressor with regulated air take-off whereby a plurality of tools or devices could also be powered through the air compressor utilizing various forms of fittings, such as quick disconnect fittings known in the art.

In a particular preferred embodiment, the efficient liquid droplet size may have fixed or variable flow capabilities, which can be gravity or siphoned fed, and facilitated through the use of at least one nozzle (single or multiple). The nozzle utilized in the present invention may be fed by gravity, siphon, pressure feed, or other pressure fed internal or external mix design. For instance, the present invention may utilize a Venturi-type nozzle, a high-pressure nozzle, hydraulic nozzle, siphon or gravity fed air assisted nozzle, air atomizing nozzle, blow-off nozzle, ultrasonic nozzle, thermal nozzle applications and technology, and all other forms of atomizing or spray nozzles. Although it is contemplated that a preferred nozzle is a Venturi-type nozzle configuration, it should be seen that the present invention may also comprise any number of liquid pressure fed nozzles, having either an internal or external mix, as well as the use of a pressure fed pump configuration. Generally speaking, air assisted nozzles provide very fine droplets that are smaller in size than traditional nozzles. The nozzle of the present invention may or may not have drip characteristics and/or automatic self-cleaning features to reduce the maintenance and clean-up demand depending upon the selected application or spraying environment. Further, the nozzle design of the present invention may incorporate and utilize a variety of patterns such as flat, full cone, hollow cone, fan, etc.

The present invention further serves to provide a method or technique for the application of liquid materials, such as insecticides, pesticides, and herbicides, natural or synthetic, for the reduction and control of mosquito populations, through the use of spraying kit or set of components which can be mounted and/or transported in the bed of a vehicle or other transportation device. For example, such components could be mounted within a land transportation vehicle, attached to a backpack type configuration for mobile use, or be used as an attachment to conventional lawn and garden equipment, such as a leaf blower, tractor, lawnmower, or the like. The spraying of the droplet particles can be effectuated in accordance with the teachings of U.S. Pat. No. 5,873,530 ("Liquid Atomizing Spray Gun"), WO 99/43441 ("Sprayer For Liquids And Nozzle Insert"), and WO 99/39834 ("Spray Apparatus"), all of which are hereby expressly incorporated by reference. More particularly, the present invention and system may achieve atomization of a material selected for application in a wide variety of ways. For example, the liquid may be atomized through mechanical shearing, high-pressure air atomization, high-liquid pressure, or vibration. Further, the specific objects, specifications, features and improvements of the present invention can be briefly summarized as follows:

In a first preferred embodiment, the present invention is a regulated flow of a liquid material spraying machine that is composed of at least four major components: a direct drive engine and compressor assembly, a fluid formulation tank and attachments, an air tank frame assembly, and a nozzle assembly. The nozzle assembly is preferably a specialized nozzle that creates uniform droplet output and provides for an air-activated nozzle clean-out feature.

Other preferred embodiments of the invention include additional features such as a spraying device that includes two separate units formed of the above components that are easily combined or broken down for shipping, a spraying device that may be attached to a pre-existing portable air compressor and a spraying device providing a variable flow Ultra Low Volume liquid formulation spraying.

These and other objects of the present invention will become apparent upon reading the following detailed description in combination with the accompanying drawings, which depict systems and components that can be used alone or in combination with each other in accordance with the present invention.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** illustrates a perspective view of a first preferred embodiment of the present invention.

FIG. **2** illustrates a cross-sectional view of a Venturi nozzle of the present invention in a spray ON position.

FIG. **3** illustrates cross-section A—A of FIG. **2**.

FIG. **4** illustrates cross-section B—B of FIG. **2**.

FIG. **5** illustrates a cross-sectional view of a Venturi nozzle of the present invention in a spray CLEAN position.

FIG. **6** illustrates a cross-sectional view of the spray circuit of the present in a spray ON position.

FIGS. **6**A and **6**B illustrate cross-section A—A of FIG. **6** showing a fixed and variable restriction, respectively, for the liquid supply line.

FIG. **7** illustrates a cross-sectional view of the spray circuit of the present in a spray CLEAN position.

FIG. **8** illustrates a cross-sectional view of the spray circuit of the present invention in a spray OFF position.

FIGS. **9**A and **9**B illustrate additional structures for use with the present invention.

FIG. **10** illustrates a perspective view of a second preferred embodiment of the present invention.

FIG. **11** illustrates a perspective view of a third preferred embodiment of the present invention.

FIGS. **12**A–**12**D illustrate attachment devices used in conjunction with the present invention of FIG. **11**.

FIG. **13** illustrates a perspective view of a fourth preferred embodiment of the present invention.

FIG. **14** illustrates a cross-sectional view of the fourth preferred embodiment of the present invention.

FIG. **15** illustrates a flow chart of the method for use of the fourth preferred embodiment of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

A number of advantages are realized in accordance with the present invention, including, but not limited to, the ability to deliver and apply a liquid atomized spray to targeted portions of the ambient environment.

With reference to FIG. **1**, a first preferred embodiment of the present invention is there shown and includes a spraying

device **10** able to produce a precise degree of liquid droplet generation on a repeatable basis by combining a specified rate of regulated flow of a liquid material with a targeted and regulated flow of high-pressure air.

Specifically, the spraying device **10** includes an engine driven direct drive compressor **12** that can be powered by electricity, gasoline, diesel fuel, ethanol, kerosene, hydraulic, air motor, electrical motor, fuel cell technology, or the like. In addition, the engine driven compressor **12** can utilize direct drive, belt drive, chain drive, or gear driven technology known in the art. Coupled to the compressor **12** is at least one, and more preferably two, air storage tank **14**. These tanks **14** provide air pulsation reduction to the regulated air stream and also serve as a reservoir for excess airflow generation. Intermediate the compressor **12** and storage tanks **14** is an automatic engagement switch **16**. The compressor **12** is engaged and disengaged from generating high-pressure air to the reservoir storage tanks **14** by means of the automatic engagement switch **16**. A specialized Venturi nozzle **18** is connected to the compressor **12** via a manual switch **20**. During operation, the regulated airflow is applied from the compressor **12** to the nozzle **18** via the manual switch **20**. The nozzle **18** is also connected to a reservoir tank **22** by a liquid supply tube **24**.

FIGS. **2–8** illustrate the preferred method for operating the spraying device **10** and the interior workings of the Venturi nozzle **18**. In this embodiment, the manual switch **20** is preferably a 4 way, 3-position manual control pneumatic valve with an operating pressure of 200 p.s.i. (13.8 bar.) The switch **20** is preferably a closed center valve. When the switch **20** is in the ON position (FIG. **6**), the spool **26** is pushed in placing the spraying device **10** in "spray" position. The air pressure in the switch **20** is routed through an outlet **28** leading to a nozzle air inlet **30** (FIGS. **2**, **5** and **6**). Once inside the nozzle **18**, the air forces the piston/needle assembly **32** backward toward the interior rear end **34** of the nozzle **18**. The compressed air is then ejected through Venturi injectors **36** (FIGS. **2** and **4**) into the nozzle cone **38**. As the compressed air is ejected through the Venturi injectors **36**, a vacuum is created that constantly draws fluid **40** up from the reservoir tank **22** located below the nozzle **18**. The fluid **40** enters the nozzle cone **38** at the fluid inlet **42** forward of the air inlet **20**. The compressed air passes through the fluid **40** pulverizing the liquid into a fog **42** that is propelled into the ambient air. If the compressed air fails, no vacuum is formed and fluid **40** will not draw from the reservoir tank **22**, making the nozzle **18** dripless. Additionally, if any air remains trapped behind the piston/needle **32** within the piston/needle chamber **44** when the piston/needle **32** is forced rearward, the air escapes through the control valve's **20** exhaust port **46**.

The Venturi design of the nozzle **18** causes a vacuum or low-pressure area to be generated in the liquid supply tube **24** extending from the nozzle **18** toward the reservoir tank **22** when the high-pressure air is exiting the nozzle **18**. The liquid supply tube **24** may use a fixed **24**A or variable restriction **24**B (FIGS. **6**A and **6**B. respectively) to regulate the liquid flow to the nozzle **18**. The low-pressure vacuum in the liquid supply line then draws this regulated liquid flow or alternatively, the liquid **40** is pushed up the tube **24** by the higher pressure atmospheric pressure being applied to the liquid **40** in the reservoir tank **22**, and mixes the liquid externally with the regulated high-pressure air in exacting proportions forming specified liquid droplet sizes. This air/liquid ratio at regulated pressures is critical to repeatable and predictable liquid droplet size generation. Because the spraying device **10** uses both air and liquid regulation combined with a Venturi nozzle, the device **10** is able to generate extremely consistent liquid droplet sizes.

When the switch **20** is in the off position (FIG. **8**), spool **26** is centered. Both air outlets **28**, and air exhaust port **46** are blocked and as a result, no air is allowed to pass through the valve switch **20** to either inlet **30**,**42** of the nozzle **18**. Since the Venturi nozzle requires compressed air flowing through the nozzle to siphon fluid from the lower reservoir tank **22**, no fluid flows through the system in this position, making the nozzle **18** dripless.

To clean out the nozzle **18** (FIGS. **5** and **7**), the spool **26** on control valve **20** is pulled out, thereby routing the compressed air through the control valve **20** into the exhaust port **46** leading to the rear end of the nozzle **34**. Once inside the piston/needle chamber **44** of the nozzle **18**, the compressed air forces the piston/needle assembly **32** forward allowing the air on the front side **48** of the piston/needle assembly **32** to exit the nozzle **18**. The cleaning needle **50** is located opposite the piston of the assembly **32** and is forced out of the nozzle **18** into the ambient air clearing away any debris in the nozzle tip **52**. This clean out feature allows the operator of the device **10** to clean any obstructions from the nozzle **18** without any nozzle disassembly or machine shut down.

An advantage of the device **10** is that the reservoir tank **22** with nozzle **18** may be located on an adjustable arm **53** as shown in FIGS. **9**A and **9**B, allowing the spraying component of the device to be vertically adjusted between a lower position (FIG. **9**A) and a higher extended position (FIG. **9**B.) This allows an operator to reach ceilings or other high areas, such as trees, while spraying without having to elevate the entire device. A still other advantage is that the device **10** may be equipped with a shield **54** having a support arm **56** for holding the nozzle **18** in position. The nozzle **18** with reservoir tank **22** may be adjusted vertically and the nozzle **18** aimed in a desired position. The operator may be in a distant location and able to operate the device either manually or remotely to protect themselves from the dispersed fluid. The shield **54** may direct and guide the dispersed fluid to a discreet area.

A second preferred embodiment is shown in FIG. **10** and comprises a spraying device **100** formed of two major components: a compressor air tank and frame assembly **110** forms the first component and a reservoir/nozzle assembly **112** forms the second component. The independent components **110**,**112** are preferably proportioned to allow for separate shipping by common carrier. The reservoir/nozzle assembly **112** is removably attachable to the frame assembly **110** by means of a drop-on cradle **114** preferably in the form of an inverted U-shape. The reservoir/nozzle assembly **112** is attached to the cradle **114** at one end **116** and the "U" portion **118** of the cradle **114** straddles the frame **120** of the frame assembly **110** to form a two-component high performance energy efficient spraying device **100**.

The frame assembly **110** includes a gasoline engine **122** mounted on a mounting plate **124** above at least one and more preferably two air tanks **126** forming an overall low profile and stable device **100**. In a preferred embodiment, the engine **122** is a high efficiency Honda gas engine coupled to a high capacity direct drive compressor **128**, thereby eliminating all belt/pulley, chain or gear drives making this a high efficiency energy source. At least one and preferably two twin air reservoir tanks **130** are located below the engine **122** and compressor **128** and provide storage for the high-pressure air as well as providing air pulsation dampening for the nozzle air feed lines **156**. A switch **132**, preferably an

automatic switch, is located on top of one of the air reservoir tanks **130** (the right hand tank in FIG. **10**) engages and disengages the high-pressure compressor **128**. The high-pressure air is supplied from the compressor **128** to the reservoir tanks **130** by an armored feed line **134** that extends from an output port **136** on the compressor **128** to a feed port **138** on the automatic switch **132**. A air regulator/gauge quick coupler assembly **140** is located on the top of the opposing reservoir tank **130**, thereby allowing dual usage of the device **100** as a high output standard air compressor as well as a spraying device.

As described above, the reservoir/nozzle assembly **112** simply drops into position on one side of the compressor frame **120**. A flexible air feed line **142** with swivel coupler **144** attaches to a manual valve **146** preferably located on the frame **120** at a point near or at the drop on cradle **114**. At least one and preferably two Venturi nozzles **148** are mounted above a liquid formulation or reservoir tank **150** and air is directed to the Venturi nozzles **148** by moving the manual switch **152** mounted on the manual valve **146** to the ON position. Like the first preferred embodiment, the manual switch **152** is preferably a 4 way/3 position switch having an ON, OFF and CLEAN position. Additionally, the Venturi nozzles **148** are preferably similar to those shown in FIGS. **2–8** and operate as described above. The air flow passing through the nozzles **148** creates a low pressure vacuum in the fluid supply circuit and supply tubes **154** allowing the liquid formulation to be drawn up the supply circuit or, more accurately, pushed up the liquid formulation supply circuit by the higher pressure atmospheric air applied to the formulation in the liquid reservoir tank **150**. The liquid supply tubes **154** going to the tank **150** may or may not be restricted, depending on the product being used, to regulate the flow of the liquid formulation to the nozzles **148**. Strainer screens (not shown) may be positioned within the liquid supply lines **154** to eliminate or reduce nozzle plugging.

By regulating the pressure of the air to the nozzles **148**, varying degrees of droplet size generation may successfully be achieved. The high-pressure air bombards the liquid stream just as it exits the nozzle **148**, shattering the liquid stream into uniform droplets. The size of these droplets is determined by the pressure and volume of air directed at the liquid stream. A separate air feed line **156** is attached to the back of each nozzle **148** and feeds air into the exhaust port **46** (See FIGS. **5** and **7**) when the manual switch **152** is in the CLEAN position. The nozzle is cleaned as described above, allowing the operator to clean the nozzle without shutting down or disassembling the device **100** in any way.

Advantageously, the nozzles **148** are preferably made of corrosion resistant material such as stainless steel allowing the operator to use any formulation of liquid for spraying. Additionally, the reservoir tank **150** is preferably formed of ultraviolet resistant material such as plastic and preferably incorporates a wide mouth filler cap with gauge **158**. Incorporated into the twin nozzle assembly **148** is a valve, preferably a simple ball valve **160** located between the two nozzles **148** in the air supply line **156** that allows the operator to spray with one or two nozzles **148** depending on how much material output is desired. Mounted above the nozzles is a shield **162** as described above. In addition to the advantages of the shield set forth above, the shield **162** protects the nozzles **148** in case the assembly tips over as well as doubling for a carrying handle for the reservoir/nozzle assembly **112**. Overall, the device **100** allows for a preferable liquid formulation rate of up to 6 ounces of oil based liquid for atomization and higher flow rates of other products. The unit is compact, highly efficient and easily transportable.

Additional advantages of this device are that is may also be converted to a gas-powered portable compressor in seconds. The device is a self-contained unit requiring no outside power source and can is easily transported by hand or used in conjunction with a 4 wheeler, a utility vehicle, a snow mobile, a pick up truck or boat, for example, and may be provided with security straps for securing to a vehicle during transport to a remote location.

A third preferred embodiment of the spraying device **200** is shown in FIG. **11** and includes a reservoir/nozzle assembly **210** for use with a pre-existing portable air compressor. The device **200** comes equipped with several attachment devices for supporting the reservoir/nozzle assembly **210** within the vicinity of a pre-existing portable air compressor and other attachment devices for mounting the spraying device **200** to vehicles, such as truck stake pockets, floor mounts, or along side a compressor, as well as to a standard pontoon compressor carrying frame as shown in FIG. **12**.

The spraying device **200** receives all the air energy used for the liquid atomization process described above and illustrated in FIGS. **1–10**, by way of a flexible air feed line **212** with swivel coupler **214**. This flexible line **212** is coupled to any air source of appropriate capacity, such as the compressor air tank **12**, **110** described above. The flexible line **212** extends from the air source to a manual valve **216** having a 4 way/3 position switch **218** including an ON, OFF and CLEAN position as described above. When the switch **218** is in the ON or CLEAN position, air is directed at least one and preferably two Venturi nozzles **220** mounted above the liquid formulation/reservoir tank **222**. The spraying device **200** with Venturi nozzles **220** works similar to the first and second preferred embodiments described above and illustrated in FIGS. **1–10**. Like the second preferred embodiment, the liquid supply tubes **224** going to the tank **222** may or may not be restricted, depending on the product being used, to regulate the flow of the liquid formulation in the nozzles **220**. The supply tubes **224** may also include strainer screens to eliminate or reduce nozzle plugging.

Similarly, a separate air feed line **226** is attached to the back **228** of the nozzles **220** and directs air into the exhaust port **46** (FIGS. **5** and **7**) when the switch **218** is in the CLEAN position. Advantageously, the nozzles **220** are preferably made of corrosion resistant material such as stainless steel allowing the operator to use any formulation of liquid for spraying. Additionally, the reservoir tank **222** is preferably formed of ultraviolet resistant material such as plastic and preferably incorporates a wide mouth filler cap with gauge **230**. Incorporated into the twin nozzle assembly **220** is a valve, preferably a simple ball valve **232** located between the two nozzles **220** in the air supply line **226** that allows the operator to spray with one or two nozzles **220** depending on how much material output is desired. Mounted above the nozzles is a shield **234** as described above. In addition to the advantages of the shield set forth above, the shield **234** protects the nozzles **220** in case the assembly tips over as well as doubling for a carrying handle for the reservoir/nozzle assembly **210**.

With reference to FIGS. **12**A–D, several attachments are there shown for attaching the spraying device **200** to a compressor and additional devices such as a truck or other vehicles, an extending stand (FIGS. **9**A and (**9**B) or any other carrying means. FIG. **12**A illustrates a U-shaped cradle **236** as described in the second preferred embodiment above and includes an L-shaped bracket **238** for mounting attachment to a truck bed for example. Additionally, a separate bracket **240** may be provided with a U-shaped handle **242** for sliding the L-shaped bracket **238** within for supporting

the U-shaped cradle **236** and providing an attachment plate **244** with openings **246** for securing the device **200** to a flat area, such as the bed of a truck. A second bracket **248** secures the reservoir/nozzle assembly **210** within the U-shaped cradle **236**.

FIG. **12**B illustrates an attachment **250** for use with a stake box opening in the bed of a pick up truck, for instance. The attachment **250** includes a plate **252** extending horizontally atop a leg **254**. The leg **254** is generally sized to fit easily within a stake box opening. The plate **252** includes openings **256** that align with openings **246** for securing the attachment **250** to the bracket **240** and supporting the device **200** within a stake box opening.

FIG. **12**C illustrates another attachment **258** for use with the U-shaped cradle **236** when the operator desires a free standing spraying device **200**. The attachment **258** is configured with an upper plate **260** and a lower plate **262** and includes a leg **264** that extends between the plates. The upper plate **260** is preferably smaller in size than the lower plate **262** and includes openings **266** that align with openings **246** for securing the attachment **258** to the bracket **240**. Lower plate **262** is preferably large and serves to aid in supporting the spraying device **200** in an upright position on any flat surface area.

FIG. **12**D illustrates another attachment **268** for use with the U-shaped cradle **236** and includes an L-shaped bracket **270** having an upper horizontal leg **272** equipped with openings **274** that align with openings **246** on bracket **240**. At least one and preferably a pair of opposing C-shaped arms **276** are fixed to the lower vertical leg **278** of the L-shaped bracket **270** and may be used to clamp the spraying device **200** to a variety of pieces such as a bracket or frame of the pre-existing portable air compressor.

With reference to FIGS. **13–15**, a fourth preferred embodiment of the present invention is there shown and illustrates a variable flow Ultra Low Volume liquid formulation spraying machine able to atomize droplets from a liquid formulation on a consistent basis attesting to its efficient design. The spraying machine **300** is composed of five major components: an engine and compressor assembly **310**, a fluid formulation tank **312** with attachments, an air tank frame assembly **314**, an air driven liquid formulation pump **316**, and a nozzle assembly **318**. The engine **320** is preferably a direct drive engine and more preferably a Honda direct drive engine.

Although the nozzle assembly **318** is preferably a Venturi nozzle assembly and works similar to the first and second preferred embodiments described above and illustrated in FIGS. **1–10**, it should be seen that the present invention may also utilize a gravity, siphon, or pressure fed nozzle having either an internal or external mix design. The nozzle assembly **318** provides an internal mix nozzle to create uniform droplet output by combining a pressurized liquid formulation with a high-pressure air prior to the mixture being forced out of the nozzle tip **322**. The resulting extremely high turbulence from the forces applied inside the nozzle assembly **318** causes the break-up of the pressurized liquid formulation. This internal nozzle mixing mechanism provides a highly efficient transfer of energies as evidenced by the resulting high fluid output rates in relation to the horsepower input energy available to the device **300**. By combining both liquid and air forces in the manner described below, the device **300** is able to successfully achieve variable flow rates, high liquid formulation output and consistent droplet formation.

More specifically, the present invention utilizes a direct drive engine and compressor assembly **310**, wherein the engine may be manufactured by Honda, which supplies high-pressure air to one and preferably two twin air storage tanks **324**, which also comprise part of the frame assembly **314**. This high-pressure air travels to the tanks **324** through a supply tube **326** that is in engagement, such as fluid engagement, with the engine's **320** automatic engagement/disengagement switch **328**. In a preferred embodiment, the supply tube **326** is an armored supply tube. Output air is directed to at least one and preferably three separate adjustable air pressure regulators **329**, **330**, **336** creating three separate air supplies. In the embodiment comprising three separate air supplies, it should be seen that one air supply flows to the air driven liquid formulation pump **316** through line **334**, one air supply going or flowing to the nozzle assembly **318** via line **362**, and one air supply going or flowing to the damping cylinder **340** via line **332**. Pressure to the liquid formulation pump **316** is regulated to optimize pump performance as well as changing output fluid pressure depending on the liquid flow rate desired to the nozzle **318**. In a preferred embodiment, the pump **316** multiplies the liquid output pressure relative to air input pressure by a factor of up to four or more. The selected or chosen formulation fluid may be gravity fed to the liquid side of the air/fluid pump via line **331**.

The fluid, when exiting pump **316** comprised of increased fluid pressure, is directed or displaced via line **333**, **333**A to the damping cylinder **340** and fluid pressure regulator while en route or moving toward the nozzle **318**. The fluid output pressure may ultimately be regulated by fluid pressure regulator **338** located along line **333**. It should be seen that incorporated within the air/fluid circuits is a pulsation or damping cylinder **340**. The damping cylinder **340** dampens the liquid fluid pulsations to the nozzle **318** caused by the cycling of the air driven liquid formulation pump **316**. The cylinder **340** is in fluid connection with the nozzle assembly **318** via lines **332** and **333**A.

The nozzle assembly **318** is fixedly attached to a mast **342** that is pivotal from a vertical position to a fully horizontal position (shown in phantom in FIG. **13**.) The nozzle assembly **318** is also rotatable to allow for directional flow of the atomized liquid stream exiting through the nozzle **318** or a nozzle tip **332**. In addition to providing multi-directional spraying, the mast **342** may be locked in a vertical position by any type of locking mechanism known in the art. In the preferred embodiment, the mast latch **344** is a slip ring attached to the mast for locking purposes to the frame **314**.

The liquid formulation tank **312** utilizes a bottom feed supply line **331** to the pump **316** with preferably a filter screen in line or in tank to eliminate debris from entering the fluid supply line **331**. A bypass valve **350** in fluid connection with the fluid pressure regulator **338** via fluid supply line **362** to the nozzle assembly **318** allows for nozzle bypass back to the fluid formulation tank **312** through a bypass line **356** when the pump **316** may need to be purged of air, typically if the liquid formulation tank **312** is inadvertently run dry. This feature is also used for chemical agitation prior to being sprayed. A fluid pressure gauge **358** is provided in line **333** to allow for a visual check of the desired pressure during operation.

A manual switch **360** is preferably a 3 way/2 position switch having an ON and OFF position. When the switch **360** is in the ON position, air is directed through fluid lines **332**, **334**, and **362** respectively as described above. In those embodiments of the present invention which comprise a switch **360** having a CLEAN position, it should be seen that when the switch **360** is in the CLEAN position, air is directed through fluid line **362** and one of the two fluid

pressure regulators **330** to the nozzle assembly **318**. The nozzle assembly **318** and nozzle tip **322** is cleaned in the manner described above and illustrated in FIGS. **5** and **7**. Carrying handles **364** are preferably mounted on either end of the air tank frame assembly **314** for lifting, as well as at least one wheel **366** or tire mounted under the frame **314** so that the entire device **300** may be easily rolled to any location for successful operation.

It is also envisioned that the twin air storage tanks **324** may be disengaged from the fluid formulation tank **312** and advantageously used to power air tools, such as a nail gun or other where the fluid and air pressure regulators **330,336, 338** together with the pulsation dampening cylinder **340** provide a reservoir of high pressure air to the tool while reducing pulsation of air flow, eliminating spurts of air to the tool. Additionally, the nozzle assembly **318** may alternatively be a pressure fed nozzle implementing the fluid and air pressure regulators **330,336,338** with the pulsation damping cylinder **340** provided with the device **300**. This pressure fed nozzle may include an internal mix pressure feed, similar to the Venturi nozzle described above, or an externally mixed pressure feed that is well known in the art. The pressure feed nozzle may also be visually monitored by the fluid pressure gauge **358** provided with the device **330** and described above.

The preferred embodiments of the present invention have been disclosed. A person of ordinary skill in the art would realize however, that certain modifications would come within the teachings of this invention. Therefore, the following claims should be studied to determine the true scope and content of the invention.

What is claimed is:

1. A spraying system comprising:

a gasoline engine direct drive compressor for introducing a regulated air flow into the system;

at least one air storage tank in fluid connection with said compressor for reducing air pulsation within said regulated air flow;

an automatic engagement switch intermediate said storage tank and said compressor for engaging and disengaging said compressor;

a Venturi nozzle fluidly connected to said compressor via a manual switch, said manual switch applying said regulated air flow from said compressor to said Venturi nozzle, said Venturi nozzle including a nozzle cone external to and internally fluidly connected with said Venturi nozzle; and

a reservoir tank fluidly connected to said Venturi nozzle by a liquid supply tube, said reservoir tank containing a solution to be sprayed, said liquid supply line having a restriction to regulate said solution flow to said nozzle,

wherein said regulated air is compressed within said Venturi nozzle and ejected from said nozzle creating a vacuum within said nozzle and drawing said regulated solution from said reservoir tank into said nozzle cone for pulverization by said compressed air for spraying into the ambient air thereby generating consistent liquid droplets.

2. The spraying system of claim **1**, wherein said restriction of said liquid supply tube is a fixed restriction.

3. The spraying system of claim **1**, wherein said restriction of said liquid supply tube is a variable restriction.

4. The spraying system of claim **1**, wherein said manual switch is a 4-way, 3-position manual control pneumatic valve providing a means for directing said regulated air to said nozzle cone for cleaning of said nozzle without disassembly of said nozzle or shut down of said spraying system.

5. The spraying system of claim **1**, wherein said system further comprising a frame for supporting said spraying system, said frame including an adjustable arm supporting said Venturi nozzle and said reservoir tank for variable vertical adjustment of said nozzle with said tank for targeted spraying.

6. The spraying system of claim **1**, wherein said air storage tank provides a reservoir for excess airflow generation by said compressor.

7. A spraying system comprising:

a direct drive compressor for introducing a regulated air flow into the system;

at least one air storage tank in fluid connection with said compressor for reducing air pulsation within said regulated air flow;

an automatic engagement switch intermediate said storage tank and said compressor for engaging and disengaging said compressor;

a nozzle fluidly connected to said compressor via a manual switch, said manual switch applying said regulated air flow from said compressor to said nozzle, said nozzle including a nozzle cone external to and internally fluidly connected with said nozzle; and

a reservoir tank fluidly connected to said nozzle by a liquid supply tube, said reservoir tank containing a solution to be sprayed, said liquid supply line having a restriction to regulate said solution flow to said nozzle,

wherein said regulated air is compressed within said nozzle and ejected from said nozzle creating a vacuum within said nozzle and drawing said regulated solution from said reservoir tank into said nozzle cone for pulverization by said compressed air for spraying into the ambient air thereby generating consistent liquid droplets.

8. The spraying system of claim **7**, wherein said restriction of said liquid supply tube is a fixed restriction.

9. The spraying system of claim **7**, wherein said restriction of said liquid supply tube is a variable restriction.

10. The spraying system of claim **7**, wherein said manual switch is a 4-way, 3-position manual control pneumatic valve providing a means for directing said regulated air to said nozzle cone for cleaning of said nozzle without disassembly of said nozzle or shut down of said spraying system.

11. The spraying system of claim **7**, wherein said system further comprising a frame for supporting said spraying system, said frame including an adjustable arm supporting said nozzle and said reservoir tank for variable vertical adjustment of said nozzle with said tank for targeted spraying.

12. The spraying system of claim **7**, wherein said air storage tank provides a reservoir for excess airflow generation by said compressor.

13. The spraying system of claim **7**, wherein said nozzle is a Venturi nozzle.

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